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100 Years Later: An Analysis Into Factors That Affected Mortality During The 1918 Spanish Flu Pandemic

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100 YEARS LATER:
AN ANALYSIS INTO FACTORS THAT AFFECTED MORTALITY DURING THE 1918 SPANISH FLU PANDEMIC

by

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ABSTRACT

100 Years Later:

An Analysis Into Factors That Affected Mortality

During The 1918 Spanish Flu Pandemic

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The 1918 Influenza Pandemic moved around the world in three waves, infecting up to 500 million people and causing over 40 million deaths. In areas that ended the pandemic with lower mortality rates than average, several things tended to be present. These include low rates of poverty, widespread access to healthcare, well-funded and widespread public health measures, and well-managed record keeping. Areas that ended the pandemic with high rates of mortality tended to lack the above – they had high rates of poverty, access to healthcare was limited, public health measures were unfunded or ineffective, and recordkeeping and communication were unreliable or unclear. It is important to learn from the success and mistakes of nations passed so that we as a planet are better prepared for any pandemics that should arise in the future. Being prepared involves high vaccination rates, fighting drug resistant pathogens, and acting working to lower global poverty.

KEYWORDS: 1918, Spanish Flu, Pandemic, Influenza, Poverty, Public Health

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Chapter One

Introduction

Before the Storm

The year 1918 marked many events, many surrounding the demobilization and end of the First World War. The armistice was signed, the combined forces of the Entente entered Germany, and the war was brought to an end (Library of Congress, 2019). The Great War marked one of the largest losses of life from any war – over a million died in the Battle of Verdun alone (Library of Congress, 2019). So many people flooded the fronts and mud-and-shell-filled trenches, and so many people didn't leave them alive. Over 20 million people, military and civilians combined, perished by the end of the Great War (Royde-Smith & Showalter, 2019). What nobody saw coming was up to 40 million more dying in the next three years from a single disease – the Spanish Flu (Taubenberger, 2006). Up to a third of the world population, over 500 million people, fell ill because of the infection (Taubenberger, 2006). The cause of the pandemic was a strain of Influenza A, H1N1, an avian-based flu virus (Taubenberger, 2006). It moved across the world in three waves, with the second tending to cause substantially more deaths than the other two (Taubenberger, 2006). No laboratory tests were available to diagnose or characterize the virus, and no vaccines were available (CDC, 2018, May 7). In many cases, mortality arose faster than one could be diagnosed, with some fatalities reportedly arising within 24 hours of symptoms developing (CDC, 2018, May 14). The mortality rate of those infected was 2.5%, significantly higher than the .1% mortality rate for most other influenza outbreaks (Taubenberger, 2006). Some suggest this is

because of a higher incidence of severe or complicated infections in the respiratory system, while others suggest that it was due to the overproduction of proinflammatory cytokines in response to the infection, resulting in what has been coined as a "cytokine storm," which can result in multi-organ failure and would prominently affect those with more robust immune systems (Taubenberger, 2006)(Liu et al., 2016). The 1918 pandemic resulted higher rates of mortality in adults who would typically weather an influenza pandemic well, while those of more advanced age had lower mortality than expected, leading some to suspect that resistance from a previous outbreak may have been conferred and simultaneously supporting the idea of a cytokine storm effect (Luk et al., 2001).

Emergence of the Disease

The strain of influenza that caused the 1918 pandemic is thought to have originated from one of three places: England, the United States, or China. There is strong contention within the scientific community as to which is correct, with most pointing either to the Chinese origin or American origin. Those in favor of the American origin tend to believe that the outbreak started in rural Kansas. It was thought to have been spread between and amongst army training camps, and then carried out along with the troops to the fronts of WWI, where it spread throughout the multinational troops and from there, across the globe (Barry, 2004). Reasons for this include the seemingly immediate spread of flu across the European continent after the American troops arrived, and early cases of what appeared to be a mild strain of the flu in the area

before the pandemic (Barry, 2004). Those claiming China, however, assert so because of the mild nature of the epidemic (which will be explored later) the possibility that initial cases were misdiagnosed at pneumonic plague, and that the flu was spread along with the Chinese Labour Corps that were put into action and travelled the globe to support the war effort (Humphries, 2014).

The pandemic was named the Spanish flu due to the thought that it hit Spain the hardest. While the devastation that occurred in Spain is nothing short of a catastrophe, it was also a shared experience for many nations. However, of all the afflicted European powers, Spain was one of the few that was not actively taking part in hostilities, and so wartime censorship was not affecting Spanish headlines to maintain morale like it was for France, Germany, or even the United States. The first public news of the epidemic appeared in Madrid. On 22 May 1918, the influenza epidemic was a headline in Madrid's *ABC* newspaper. News stated that spread of a strange influenza-like illness, which was very mild, had been ongoing since the beginning of May (Trilla et al., 2008). Just two days before this headline, despite the infection having seemingly been in the United States longer and possibly having originated from there, on May 20th the American government passed the Sedition Act of 1918, and extension of the Espionage act of 1917 to cover a broader range of offenses, notably speech and the expression of opinion that cast the government or the war effort in a negative light or interfered with the sale of government bonds (Sedition Act of 1918, 2019). It is natural to assume that extensive deaths at the hands of the flu would lower public morale and hamper the sale of war bonds, so at the least news agencies were discouraged, if not actively prohibited,

from printing news about the influenza pandemic at the national scale, with only smaller, independent, local papers able to speak about the pandemic.

The Aftermath

At the end of the pandemic, 40 million people or more died, and up to a third of people on Earth were infected (Taubenberger, 2006). Up to 20 million of those deaths were thought to have come from India alone (Kant & Guleria, 2018). In America, nearly 700,000 died, representing a significantly greater loss of life than the first world war, whose US casualties amounted to roughly 116,000 (CDC, 2018, May 7) (Royde-Smith & Showalter, 2019). Unlike most influenza epidemics, or rather most epidemics period, the 1918 influenza strain disproportionately killed young, healthy adults from 20-40 years old, resulting in a W-shaped mortality curve with peaks in the middle of life, in infancy, and in extreme old age (Kolte et al., 2008) (Gagnon et al., 2013). One possible reason for the lower mortality in the elderly group was due to immunity granted by the Russian Cold of 1870s, a much less severe but still widespread influenza strain (Kolte et al., 2008). Others theorize that the stronger the host's immune system, the more virulent the strain was because of the release of a powerful cytokine storm that overwhelmed the host's body (Liu et al., 2016).

The economic burden of the pandemic was immediately visible as well, as the loss of a single person could result in all income for a family immediately disappearing. In Sweden, the pandemic immediately resulted in higher poorhouse rates and decreased capital returns. Despite people dying and the number of positions that should have been open and needing filled, there was no effect on wages even though an

increase was anticipated (Karlsson et al., 2014). On average, each influenza death resulted in four people moving in a poorhouse on average (Karlsson et al., 2014).

Chapter Two

Areas That Fared Well – why?

Wisconsin, United States

The United States, with power being shared between the state and federal governments, had a very diverse set of responses and outcome to the pandemic. The average mortality rate in Wisconsin was 3.3 per 1000 people, while the rest of the nation was roughly 6.5. The actions of Winnebago county, Wisconsin, may be directly responsible for this relatively low mortality rate (Shors & McFadden, 2009). Unlike many states, Wisconsin already had a state board of health, established in 1876 (Burg, 2000). Cities and towns all had their own local health officer that was part of the community, and these health officers were the main intermediary between the state and local governments (Shors & McFadden, 2009). The use of locals as intermediaries was useful for maintaining public trust and for reporting all cases of influenza so that those afflicted could be isolated and quarantined when possible to help stem the spread of the disease.

The Wisconsin's response to the arriveal of the flu was swift. Within a week, an emergency hospital had been set up, and just days after the first death schools statewide were shut down (Shors & McFadden, 2009). The state health officer, Dr. C.A. Harper, advised the closure of all schools, churches, theaters, and other places of amusement or public gatherings to help stem the spread. This resulted in a curfew for all pool halls, cafes, saloons, and restaurants (Shors & McFadden, 2009). An isolation hospital was set up, and masks from the red cross were received and immediately put

into use in an effective display of resource management and allocation (Shors & McFadden, 2009).

One of the most important reasons that Wisconsin can be considered a success is because of the public's willingness to comply with anti-flu measures. Iowa officials complained about lack of cooperation by the public with anti-influenza campaigns, despite attempting them with the same fervor as Wisconsin (Burg 2000). This is partly because anti-influenza leaders were well-known locals who were familiar with the public, as well as the outbreak occurring at the tail-end of world war one, where there was plenty of morale and wartime patriotism (Burg 2000). To fight the pandemic was the fight the Kaiser. If the population is unwilling to go along with public health measures, there might as well not be any measures to speak of. The local and state governments need to work together to construct and execute an effective response to any epidemics.

The state showed an effective, organized system of record keeping and information dispersal. Informational pamphlets were printed with multiple languages (even German, despite the war and raging anti-German sentiment) to assist with Milwaukee's large immigrant populations (Burg 2000). In addition to this, a system of card files to monitor the progress of all known cases ranked by severity was established so that cases that needed more attention could be kept track of (Burg 2000).

The fight against the flu wasn't without its hurdles or hiccups, however. Dr. Harper had ordered all schools closed, but using somewhat vague wording, leading to some areas not believing the order was mandatory. As a result, a city called Wausau

didn't close schools immediately, resulting in the worst flu outbreak in the state (Burg 2000). This simply underlines the important of clear, explicit language and proper communication, because a few unclear words resulted in the death of Wisconsin citizens. In addition to this, there was some backlash to the ordered closure of all public places. Some churches were refusing to close in order to comfort those who had lost love ones to the pandemic, and they weren't closed until the Archbishop of Milwaukee directly ordered them to (Burg 2000).

Despite these small setbacks, Wisconsin represents a victory in the fight against the pandemic. Its well-established public health system, cooperation between state and local governments, and detailed recordkeeping were all essential in maintaining a mortality rate less than half the national average.

Winnipeg, Canada

Winnipeg, Canada, had an average mortality rate of 6.1 deaths per 1000, which is slightly lower than, though comparable to the nation's national average (Zhang et al., 2010). Compared to Montreal, another large Canadian city, Winnipeg had significantly decreased cases. This is likely due to being better prepared for flu's arrival through increased public health control measures, as well as being significantly farther inland and away from trading ports. This is further evidence that an effective, organized healthcare response correlates with decrease fatality and cases of influenza. Unfortunately, it also supports the notion that increased global connectivity may have the consequence of increased transmission of disease in the event of a pandemic.

Copenhagen, Denmark

Denmark, a nation right next to the front of the first world war, saw 900,000 people contract the disease between 1918-1920, while 1 in 50 died (Kolte et al., 2008). Like most other nations, Denmark experienced a W curve for mortality over ages, with peak mortality from 20-34 years old. Unlike most other afflicted areas, however, the first wave was deadliest for Denmark, and unfortunately provided little immunity for the second wave at the population level (Kolte et al., 2008). Gathering mortality data was difficult for Denmark, as assessing the health of the countryside was unreliable because of a lack of proper death certificates (Kolte et al., 2008). In addition to this, attempting to figure out the path of infection throughout the Scandinavian nation was unreliable due to a highly-mobile population (Kolte et al., 2008).

Oddly enough, population centers like Copenhagen did better that provincial towns despite the increased transmission that accompanies rises in population density (Kolte et al., 2008). This is most likely because of increased access to healthcare in cities compared to the countryside. Copenhagen, the nation's capital, averaged 750 inhabitants per doctor, while the rest of the country averaged 2107 inhabitants per doctor. Similarly, Copenhagen averaged 112 inhabitants per hospital while the rest of the nation averaged 305 per hospital (Kolte et al., 2008). Less crowded hospital conditions likely played a role in reducing the number of transmissions between patients and hospital staff. This, in addition to allowing physicians to tend to each patient more and pay attention to specific patient needs, was likely a key factor in reducing mortality in the capital. Increase physician attention to each patient would

allow for secondary infections that commonly plagued influenza patients to be more closely monitored and treated.

Copenhagen's success and the countryside's loss is direct evidence for increasing access to healthcare, because even though increased transmission should have occurred in Copenhagen due to higher population densities, lower mortality rates were achieved with better and more accessible healthcare.

China

China, a possibility for the origin of the 1918 pandemic, found the flu milder and less lethal compared to the rest of the world (Cheng & Leung, 2007). This is despite high population densities, widespread poverty, and the presence high-traffic ports that spread goods across the globe and were frequented by foreigners (Cheng & Leung, 2007). Some argue that this in and of itself is evidence for China being the origin, as a previous, milder wave would have given partial immunity to the more vicious later waves. Others argue that the use of traditional herbal medicine was helpful in treating those with the disease. A couple years before the outbreak of the flu, China was plagued with a milder disease whose symptoms aligned with what would be the Spanish flu. However, it was diagnosed as pneumonic plague. If incorrect, which is possible given most of China's lack of equipment to properly identify the bacteria responsible, then this very likely could have been a precursor wave of the flu granting immunity to the later, more virulent waves (Humphries, 2014). This would explain most of China's easy time with the pandemic despite so many factors suggesting that they should have been

hit like India was, with as many as 20 million dead (Kant & Guleria, 2018). Until this has been confirmed, though, the reason for China's success may very well remain a mystery.

Chapter Three

Areas That Fared Poorly – Why?

Spain

It feels most appropriate to start with the 1918 influenza's namesake, Spain. The pandemic was particularly damaging in Spain, where higher estimates place the death toll at over 260,000 – a significant number for a country whose population is just shy of 20 million (Trilla et al., 2008). This can be traced back to both the ineffective measures that were put in place by the Spanish government to contain the outbreak, as well as the various socio-economic problems plaguing the divided nation. A large proportion of the country's population was impoverished due to a lack of trade and supplies due to the Great War, the inflation rate was over 20%, and the incidence of general strikes was increasing (Trilla et al., 2008). The Spanish government put several infection-control measures into place, such as limiting traffic between itself by stopping trains and prohibiting Portuguese workers from exiting trains between their stop and Portugal (Trilla et al., 2008). Unfortunately, this did not stop the spread within the country. Spanish military training camps acted as startingly-efficient mode of transmission; sick military personnel were relieved from duty and sent home by train to rest and receive medical care, rather than be put in quarantine (Trilla et al., 2008). This allowed infected individuals to rapidly spread the disease not only back in their home town, but to any fellow travelers as well, who may or may not have been going to entirely different destinations across the Iberian Peninsula. This is exacerbated by the timing of the initial outbreak – late summer, a time period full of tradition holidays (Trilla et al., 2008).

These involved large parties and widely-attended Catholic masses, and so many fell ill following the celebrations that many confused the sickness with food poisoning (Trilla et al., 2008). Even when schools and universities were closed, other public gatherings, such as church services, theaters, and cinemas, stayed open (Trilla et al., 2008).

Spain's reaction to the pandemic was inadequate and resulted in higher rates of infection and death, but factors that were outside of the government's influence played a significant part in allowing the virus to spread and wreak havoc. Spain was a neutral nation in world war I, and still the war and the disruption of trade that it brought managed to impoverish a large proportion of the population and make them more susceptible to disease. This highlights the important of avoiding the wars of times past, because even noncombatant and neutral nations will pay a steep price.

Italy

Italy, too, was not spared from the pandemic. Italy had one of the highest mortality rates in Europe at 10.7 per 1000, which is not unexpected for a nation on the front of world war one (Percoco, 2016). However, the Southern regions, despite being farther from the war front, had higher mortality. Southern Italy in the last 150 years has been falling behind the North economically because of the south's preference for farming and the north's for industrialization, leaving more of its citizens impoverished and susceptible to infection (Bohlen, 1996). The pandemic did not help with this, however – the loss of human life in these regions decreased economic growth, exacerbating the conditions an already worse-off area (Percoco, 2016). In addition to this, severe influenza pandemics have been found to have a negative effect on the

educational or socio-economic outcomes of those afflicted, so the pandemic resulted in huge loss of life as well as lower quality of life for those who survived (Percoco, 2016). The evidence here, in addition to that of Spain, clearly shows that regions with lower qualities of living will be harder hit by disease and need special care and attention shown to them to stop preventable loss of life.

Bloemfontein, South Africa

South Africa at the time of the pandemic was not independent, but rather a dominion of the British Empire (Richardson, 1911). This tie to the United Kingdom, one of the main players at the front of the Great War, is likely what resulted in the spread of the disease to South Africa via one of its ports. South Africa's fight against the pandemic is captured by the struggles of a single city – Bloemfontein, which had a population roughly 30,000, where approximately half the of population was black and the other half white (Phillips, 1987). The city put up an admirable fight, and quickly responded to the pandemic with a number of measures. This included house-to-house visits to survey the severity of the outbreak, appeals to avoid gatherings and places of entertainment, and the establishment of an official bulletin to help spread information to the public (Phillips, 1987). This public bulletin was less for spreading news about the outbreak itself, however, and more for trying to maintain public morale, such as by attacking the character of healthy citizens who were not helping or volunteering their services to the city's fight (Phillips, 1987). Other acts from the city included increasing overall access to medical care (for whites), aiding the more impoverished citizens by opening soup kitchens (for whites), and suggesting that white families keep their servants in the family

home so that they would be less likely to be infected and in turn keep the family from being infected (Phillips, 1987). The city directly managed resources by coordinating volunteers, buying, creating, and selling medicine at cost (to the anger of for-profit pharmacists) (Phillips, 1987). Bloemfontein's style was not to ask for cooperation, it was to demand it – the city "brushed aside anything which they perceived as an obstacle to the successful prosecution of their attack on the centre of the epidemic" (Phillips, 1987). Despite all of these acts and interventions, Bloemfontein suffered a higher mortality rate than surrounding cities such as Port Elizabeth or Pietermaritzburg, who were much less involved in the fight against the pandemic (Phillips, 1987). Little attention was given to the slums, which were barely even acknowledged to exist until after the epidemic after they were found to have played a strong contributing factor to the severity of the epidemic (Phillips, 1987). These slums had crowded, unsanitary conditions and little was done because large portions of these slums were black, and the officials in charge of this colonial nation were white and unwilling to commit funds to what they viewed as a population undeserving of it. Reforms were reforms were placed to lower white poverty, but very little was done for blacks even though the two sectors of town where they lived were "inextricably linked" (Phillips, 1987). This blatant discrimination without a doubt played a significant part in not just Bloemfontein's, but all of South Africa's fight against the pandemic. Poverty must be fought regardless of skin color, because microorganisms don't care what their host looks like. The Spanish Flu looked at the nation's diverse population only humans, not black humans or white humans. Had the

South African government done the same, their response may have been more successful.

India

India had the largest number of deaths in any single country (10-20 million) as well as highest percentage of excess deaths (4.39%) in the world (Kant & Guleria, 2018). At that time, it was under British colonial rule, and known as the British Raj. One of the most striking characteristics about the British Raj was its poverty and low standard of living, especially compared to when the subcontinent was independent under the Mughal Empire. The Indian economy under colonial rule was deindustrialized, citizens had a lower per-capita income, and had a large decline in the secondary sector, all indicative of a worse-off economy (Cypher, 2014) (Moosvi, 2015). India was in a poor place, economically, and this combined with an extremely large population is likely the key factor resulting in their tragic mortality rate.

Chapter Four

Lessons Hard Learned

Public Health Infrastructure and Spending

Well-integrated public health systems with large amounts of funding tended to be found in areas that had lower death rates due to the flu. Places with more care providers and beds available were more able to take care of their ill. This was seen in urban Danish cities and in our Wisconsin example. This is because an established healthcare system allows for rapid response to disease and for more attention to each patient to be given. Places with a less-established and poorly funded public healthcare system tend to have slower responses, causing diseases to be spread and for patients to possibly die while they wait for care. This was one of the key factors resulting in increased mortality in rural Danish areas compared to the cities like Copenhagen. Making healthcare more widely available and maintaining its ability to rapidly respond through adequate funding will prepare nations in the future for a pandemic and help reduce the cost that is incurred through large losses in life.

The direct effect of defunding public health systems has already been seen. The National Health Service (NHS) in the UK has gone through multiple funding cuts in the last ten years, and cuts to the public health system between just 2010 and 2014 were linked to up to 56,000 deaths (Watkins et al., 2017). By 2020, this number is expected to increase by roughly 100,000, with mortality focused in the elderly (Watkins et al., 2017).

The easiest way to decrease unnecessary death on a national scale is to increase public health funding to make sure that access to healthcare is as high as reasonable possible.

Medicine

In 1918 experts weren't sure what caused the flu – some suspected bacteria, because that was the scope of our knowledge and many secondary infections were due to bacteria (Humphries, 2014) (Morris et al., 2017). The idea of a virus and its ability to cause infection had only just been discovered, when the yellow fever virus was filtered and isolated in 1901, and we didn't have reliable methods to isolate and discover new species of virus for years (Woolhouse et al., 2012). Not knowing the origin of a disease makes it significantly more difficult to treat unless that disease in endemic to the region and traditional medicine has been developed. Traditional medicine in China is thought by some to have contributed to the lower death rate, in addition to the possibility of prior resistance, so it is not to say that treatment is impossible if the origin is not known (Cheng & Leung, 2007). More often than not in western nations, though, more extreme drugs were used to cover the symptoms. This would include blood-letting, oxygen therapy, vaccines against *H. influenzae* (which was originally thought to be the cause of the 1918 pandemic), or even heroine, powdered opium, cocaine, morphine, or diluted glycerin (Threats et al., 2005) (Shors & McFadden, 2009). Now, though we have access to equipment allowing physicians and other care providers to reliably diagnose not just the species of microbe infecting a patient, but even subspecies and trace strains so that treatment can be more personalized than ever. Generic antibiotics and antivirals are widely available.

Increasing our capability to accurately diagnose and reliably treat novel diseases is a key defense against what we don't know. Funding scientific research is one of the best preventative methods humanity can employ in the fight against the next pandemic.

Communication and Record-Keeping

Record keeping has gotten more and more reliable with the advent of digital storage, and has become common place to pull up extensive medical histories of every individual patient in order to track their treatment history and personalize new treatments. Not only is this more important for specialized and personalized patient care, but it's also useful for providing epidemiological in the future. One problem researchers faced when trying to detail the spread of the Spanish flu was inconsistent record keeping. For example, Scotland appeared to have been hit by the pandemic sooner than the rest of Britain, but in reality, the records and deaths had just been recorded in a different manner, and when examined more closely there was no substantial difference in the timing of the arrival and spread of the pandemic (Johnson, 2004). At most, they were a week apart. If this hadn't been noticed and it was taken at face value that Scotland had been hit significantly early, this could have had significant effects on the theoretical spread of the disease and altered future prevention measures for the worse. The past is how we learn and adapt for the future, and if we have an inaccurate account of the past, we will be less able to prepare for the future.

Clear communication is also imperative for an organized response to an outbreak. When directions are unclear, results will vary, often to the detriment of the public's health. For example, when the order for all schools in Wisconsin to be shut

down went out, the directions were vague enough that one city, Wausau, kept their schools open longer, exposing children, teachers, and parents to the disease and making it spread farther than it would have had the children been kept at home (Shors & McFadden, 2009). This is very likely the reason why Wausau had one of the largest outbreaks in the state.

Poverty

Poverty level was one of the largest indicators of how susceptible a population was to the Spanish Flu. Spain, Southern Italy, the slums of Bloemfontein in South Africa – all had higher infection and mortality rates than regions with lower poverty rates (Trilla et al., 2008) (Phillips, 1987) (Percoco, 2016). The reason the phenomenon occurs is relatively simple - the living conditions that typically accompany poverty also increase the transmissibility and severity of a disease. For example, poverty is typically accompanied by poorer sanitation, hygiene, and higher population densities, all increasing the rate at which a disease can spread (Hansen & Paintsil, 2016). It also lowers access to healthcare and coincides with an increased likelihood of malnutrition, both of which will act to lower the ability of a patient to fight off and survive an infection (Loignon et al., 2015) (Hansen & Paintsil, 2016). Lowering poverty rates is one of the first things that we as society needs to do if our goal is to help prevent death on a mass scale if, or rather when, the next pandemic strikes.

Mass Movement and Trade

Mass movement and wartime mobilization facilitated the spread of the Spanish flu across the entire globe. While thankfully the level of mobilization for war seen in the two world wars hasn't been seen again, humanity is still the most connected it has ever been. In under 20 hours, a human being can be in almost any major urban center because of our mastery of flight – a plane ride from Singapore to New Jersey is under 19 hours, for example (Rosen, 2019). Public transportation within cities has come a long way since 1918 in order to keep up with increasing population growth and density, and even during WWI public transport facilitated the spread of disease through the cities and through industrialized areas. Railroads were especially important in spreading the flu across Europe, as railways were almost constantly moving to transport workers and munitions. This how it possibly reached Spain - heavy railroad traffic of Spanish and Portuguese migrant workers to and from France to support the war effort and replace the workers who became soldiers (Trilla et al., 2008).

Increased global connectivity is going to make quarantines harder to enforce as well. Australia was saved from the first two waves of the pandemic because of a strictly enforced quarantine across the nation, but it was lifted too early and 40% of the nation fell ill because of the third wave, killing 15,000 (Crescent, 2019). Just lifting the quarantine too early had grave consequences – being unable to enforce it entirely would no doubt have similar effects. The global economy is more interconnected than ever – stopping or slowing trade is likely to have far-reaching consequences that effect beyond just the nation in question. Even just interrupting trade between two countries,

such as increased tariffs placed on Chinese goods by the US government, has had increasingly negative effects (Donnan, 2019) on the US economy. If this idea were to be expanded to every nation cutting trade entirely and attempting total self-sufficiency for the sake of quarantine, the resulting economy downturn and lack of goods and services result in the same levels of poverty that left Spain so vulnerable to the pandemic. If the quarantine is held and a strong economic downturn occurs, any mistakes or lapses in protocol that let in the pandemic could have much more grave consequences than simply letting the pandemic run its course would have.

Quarantine and travel restrictions can work on smaller scales, like they did for Ebola, but the economic impact of doing so on large, industrialized nations may very well outweigh the damage done by the pandemic itself. Other solutions will have to be found.

Chapter Five

The Good News

Scientific Advancements

Treatment of disease, both infectious and noninfectious, is orders of magnitude better than it was even a hundred years ago. Antiviral therapy is now widely available, and genome sequencing of the 1918 influenza virus has been done, where as in 1918 scientists weren't even sure the pandemic was caused by a virus. We have faster, more accurate diagnosis – molecular diagnostics can detect not only individual species of bacteria, but even distinguish between the multiple strains within that species (Poste, 2001). Genetic counseling allows primary care providers to access an individual's risk to disease on a level never before possible – it allows conditions to be treated before they even begin to show symptoms (Resta et al., 2006).

Vaccination was around well before the onset of WWI. Inoculation against diseases such as smallpox had been taking place for centuries, and a vaccine using heat-killed broth cultures allowed for the development of immunity against diphtheria and tetanus. ("Vaccines: Past, Present, and Future - Vaccine Supply and Innovation - NCBI Bookshelf," 1985). In WWI, the British learned first had the importance of vaccination when their soldiers had an astonishing rate of tetanus, at 32 per 1000, because they were not deploying tetanus antitoxin, whereas the American soldiers, for whom the antitoxin was required, had a rate of only .16 per 1000 ("Vaccines: Past, Present, and Future - Vaccine Supply and Innovation - NCBI Bookshelf," 1985). However, the vaccines

created often had a much higher rate of death and a lower efficacy than modern vaccines ("Vaccines: Past, Present, and Future - Vaccine Supply and Innovation - NCBI Bookshelf," 1985). It's important that vaccine-creating technology continue to advance so that if a new pandemic arises, we can quickly develop and deploy an effective vaccine.

Public Health Improvements

Healthcare in most nations is significantly more available than it was a hundred years ago. With the introduction of Medicare and Medicaid in 1965, and more recently the passing of the Affordable Care Act (ACA) in 2010, a significant number of Americans have been able to more easily gain access to necessary health care (Obama, 2016). Even in the last ten years the United States as seen an increase in the quality of care. Between 2010 and 2014, there was a 17% drop in hospital-acquired infections, which is equivalent to preventing roughly 87,000 deaths (Obama, 2016). There is also evidence for the ACA slowing the growth of health care costs, one of the largest barriers to treatment and healthcare access in the US (Obama, 2016).

In 1960, roughly 1/3 of the world lived in cities; by 2015, this had increased to 54% (World Bank, 2019). An increase in urbanization has many consequences, but luckily one of them is increased access to healthcare (WHO, 2010).

In addition to this, our knowledge about sanitation and hygiene have approved significantly, and cleanliness is closely monitored and maintained within hospitals to reduce the chance of infection (Mehta et al., 2014). There are more hygienic protocols

to protect patients, involving glove use, sterilization, handwashing, and even hair and nail care regulations (CDC, 2018, June 15).

Poverty Reduction

Poverty levels are dropped rapidly across the globe, and with that comes better nutrition and access to healthcare. Since 1990, more than 1.1 billion people have been lifted out of poverty (World Bank, 2018). East Asia, the Pacific region, Europe, and Central Asia have reduced their rates of poverty to under three percent, and overall global poverty has fallen to under 10% (World Bank, 2018). Currently, the greatest concentrations of the globe's poor are in South Asia, with over 200 million, and Sub-Saharan Africa, with over 400 million people living in extreme poverty (World Bank, 2018). Already work is being done in these regions to help alleviate the situation. India, a nation with, as of 2011, more than 20% of their nation under the poverty line, has been cutting drug prices and expanding medical coverage into order to increase their access to medical care and improve their quality of life (ABD, 2018). For example, drugs used for treating tuberculosis, psoriasis, ulcerative colitis, the flu, arthritis and more have had their prices cut by between 30 and 50% (Rajagopal, 2017). In addition to this, Cipla, an Indian company know for producing a large range of generic drugs, is cutting their cancer treatment drugs' price by up to 75% (Ahmed, 2012). In addition to cut drug prices, India has launched a new public healthcare system designed to provide a set amount of free treatment to almost 500 million of the nation's citizens, and will cover up to 500,000 rupees (approx. 7,200 USD) worth of treatment per year, a huge step in ensuring that even the nation's poorest can remain healthy (Kumar 2018).

Chapter Six

The Bad News

Higher Population Densities

Higher population densities correlate to higher rates of disease transmission, and given that there are more than seven times more people in the same amount of space compared to 1918, disease is likely to spread much, much faster within and between communities (Zelner et al., 2012). This trend isn't going to go away, either. The population in the world is currently (2018-2019) growing at a rate of around 1.07% per year, resulting in a population increase of an estimated 82 million people per year (Current World Population, 2019). This provides more avenues for disease to spread, as to accommodate higher populations, there has been an increase in transportation capability and public transport. One cannot simply address or fix this problem because the problem is people – there are just too many, and getting rid of people is not an option. This is a problem that will have to be tolerated, not removed or solved.

Global Movement and Transportation

A consequence of increasing population density, as stated, is increased public transport. Additionally, our transportation technology has come a long way from 1918. Air travel allows people to be on the other side of the globe in under a day, which means that disease can spread across the entire globe in an astronomically shorter amount of time than in 1918. This makes slowing or stopping the spread of infection

very difficult, but not impossible. Island nations already do thorough screenings of immigrants to make sure that foreign biomatter and species being introduced to the island are limited to protect the relatively fragile ecosystems. For example, New Zealand either places plant and animal products, as well as anything that could introduce microorganisms like soil, into quarantine until they are judged safe, or they are restricted from entering entirely (Ministry for Primary Industries, 2019). Initiating temporary quarantine for all individuals and all goods capable of acting as fomites for a hypothetical pandemic from entering the country would be expensive – possibly too expensive for a trade-dependent economy like New Zealand (New Zealand Ministry of Foreign Affairs and Trade, 2019). Unfortunately, it seems as though the nations that are physically isolated from others and would thus have the best capability of maintaining a full quarantine are also the nations that are also the ones whose economies are most reliant on trade with foreign markets.

The Antivaccination Movement

We are one of the first generations not experience first-hand what disease like measles, polio, or smallpox could do. People forgot what these diseases looked like, and combined with now-defunct research, have started seeing vaccines themselves as more dangerous than the possible disease. This is extremely detrimental because only a 5% drop in vaccination rates could cause a tripling in the number of measles cases in children in the United States, in addition to 2.1 million dollars in public health costs that could have gone to funding treatment against diseases that weren't preventable (Lo & Hotez, 2017). In Europe, measles cases quadrupled between 2016 and 2017, primarily

effecting unvaccinated individuals (WHO, 2018). In 2017, a 75-case outbreak was reported in Minnesota in a Somali-American community with poor vaccination coverage. In 2018 the U.S. experienced 17 outbreaks - three outbreaks in New York State, New York City, and New Jersey, respectively, contributed to most of the cases. Some of these were linked to unvaccinated individuals in Orthodox Jewish communities and to travelers who brought measles back from Israel, where a large outbreak was occurring. 82 people ended up bringing measles in to the US in 2018, greatest number of imported cases since measles was eliminated from the U.S. in 2000. The US was not alone in this, however - multiple measles outbreaks were reported across the globe. The majority of these occurred in people who were unvaccinated, but not all of them (CDC, 2019). This highlights in the importance of herd immunity in suppressing the outbreaks of disease and protecting individuals who cannot gain adequate immunity from vaccines or are immunocompromised. In 2011, more than 30 countries in the Europe reported an increase in measles, and some of these resulting in the important of measles to other countries like the United States (CDC, 2019).

Unvaccinated individuals can spread disease to nations whose vaccination rates are lower than ideal, reintroducing it and giving it the possibility of starting an epidemic. In 2019, a French family visited Costa Rica, and the child ended up reintroducing measles to the area because he wasn't vaccinated. While thankfully this didn't result in an epidemic or serious outbreak, it does highlight how easily it could have (Villanueva, 2019).

Multiple studies, including a 2019 one that is now the largest to date, have asserted that there is no correlation between vaccination and the development of autism. It looked at over 600,000 Danish children over a number of years to look at how likely a child was to develop autism based on whether or not they were vaccinated. It found there was no correlation whatsoever. 600,000 is a significant sample, given that the population of Denmark itself is under 5,800,000 (Hviid et al., 2019).

Vaccination may yield unforeseen benefits as well, If the Influenza A H1N1 strain that caused the 1918 pandemic were to return, getting your standard seasonal flu shot may yield resistance to it, meaning that high flu vaccination rates could easily save the global population from losing over 40 million lives (CDC, 2018, June 15).

Vaccination is a cheap, low-effort method of preventing deadly diseases, and the more people that adhere to it, the better than it works through the effects of herd immunity (U.S. Department of Health and Human Services, 2017). More information about the benefits of vaccination and their relative lack of risk compared to the possible risks of nonvaccination needs to be distributed in areas that have low vaccination rates, and more needs to be done to provide vaccines to areas that are at risk or have low access to vaccine providers.

Drug Resistance

The next pandemic might arise because our current treatment and containment methods for it become ineffective. Because microbes such as viruses, bacteria, and protozoans tend to have very short generation times, they are able to accumulate mutations quickly, increasing the likelihood of gaining a mutation conferring resistance

(Davies & Davies, 2010). Strong use of medication, such as antibiotics, provides a powerful selection pressure for these microbes to develop resistance and thrive (CDC, 2018, September 10). Some viruses, such as HIV, have to be combated with a multi-drug combination therapy to prevent resistance, but the introduction of multi-drug resistance would make this ineffective (Werb et al., 2010).

Resistant malaria has already arisen in southeast Asia. *P. falciparum* artemisinin resistance emerged on the Cambodia-Thailand border and can be found throughout Southeast Asia. In addition to this, *P. vivax* has developed strains that are resistant to chloroquine (WHO, 2010). Given that malaria is present across the tropics on multiple continents and is thought to be responsible for more deaths than any other cause in human history, the consequences of this could be far-reaching. While thankfully the protozoan is confined to the tropics due to its reliance on the *Anopheles* mosquito, it provides a useful model to study from. Resistance to antimalarial drugs is associated with increased transmission (Price & Nosten, 2001). Being unable to or less able to treat a disease will make it easier for others to contract it due to its ability to remain in an individual longer because it won't succumb to the treatment. It's also more likely to land a person in the hospital if it's harder to treat with standard medication – the appearance of chloroquine resistance in Africa led to an increase in hospital admissions (Zucker et al., 1996). This trend could result in seriously-overburdened hospitals, something that was correlated with increased mortality rates in 1918's pandemic. Being unable to treat the disease makes it more likely to kill because of a relatively unchecked infection. Drug-resistant malaria was associated with increased mortality at community level

(Korenromp et al., 2003). This effect is seen with other types of drug-resistant microbes. High rates of antibiotic resistance among common bacteria ranging from *E. coli* to *Staphylococcus aureus,* and it was reported that patients with drug-resistant infections were twice as likely to die (WHO, 2014). Viruses, too, are able to very rapidly gain resistance to antiviral drugs (Strasfeld & Chou, 2010). According to the World Health Organization, if these trends of increasing rates of drug resistance continues, an age where common and once-trivial infections can kill at high rates "is not out of the question" (WHO, 2014).

Between increased transmission, increased strain on the healthcare system from a rise in hospitalizations, and increased mortality, drug resistance could cause a new pandemic, or failing that, make a pandemic significantly worse if drug resistance was to develop while the disease is already a pandemic. It's important that effort is put in now to alter our treatment practices, such as by prescribing few antivirals and antibiotics, so that drug resistance doesn't increase in prevalence.

Chapter Seven

Conclusion

In the end, the best ways to help prevent a pandemic on the scale of the 1918 Spanish Flu is to work with and improve upon what we already have, rather than to try to change our practices or our populations entirely. We need to improve citizens' standards of living and increase their access to healthcare, because poverty has been shown to be one of the largest indicators of susceptibility to disease. This is because of previously-mentioned associations with lower hygiene, inability to pay for medical care, and the tendency for lower income populations to have higher population densities, such as cramped living spaces and urban slums. Improving hygiene and sanitation will lower the risk of transmission in these populations, and increasing public health access will allow for at-risk populations to seek treatment as needed, rather than delaying treatment for fear of being unable to meet the cost. Vaccination targets need to be met, because preventative care is much more effective and inexpensive in the long run than actively treating every individual for disease. Additionally, decreasing the demand for treatment as a result of increased immunity gained by vaccination will also help to lower the chances of drug resistance emerging, making treatment that is necessary more effective.

Regardless of poverty, some areas may have poor access to quality healthcare because of a lack of funding, inadequate facilities, or understaffed hospitals and clinicals. It's important that these be addressed, because if a patient cannot see their physician because their physician is too busy with a multitude of over patients, or they

themselves fall ill, it has the same consequence as if the patient hadn't sought out treatment at all. This problem may arise in both rural areas or urban areas, so it's important that both population types get proper attention to make sure they have access to healthcare if they need it.

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